Measurement of Design Process Front-End – Radical Innovation Approach

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Measurement of Design Front End - Radical Innovation Approach

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Abstract
The overall structure and the main characteristics of the future product are all decided in the front-end phase, which then strongly affects subsequent new product development activities. Recent studies indicate that these early front-end activities represent the most troublesome phase of the innovation process, and at the same time one of the greatest opportunities to improve the overall innovation capability of a company. In this paper dealing with the criteria we concentrate only for the objectives viewpoint and leave the attributes discussion to the future research. Two most crucial questions are:

- What are the objectives of measurement in radical design? and
- What are the most crucial future challenges related with the selection of the relevant measurement objectives?

Based on the theoretical part of this paper, our framework of the Balanced Design Front-End Model (BDFEM) for measuring the innovation activities front end contains five assessment viewpoints as follows; input, process, output (including impacts), social environment and structural environment. Based on the results from our first managerial implications in three Finnish manufacturing companies we argue, that the developed model is flexible and can also be applied extensively to other purposes than manufacturing companies, like service sector, as well.

Keywords: measurement, radical, innovation, design, development, front-end

1 Introduction

The framework of the model for measuring the innovation and design activities front end contains at the first draft five assessment viewpoints as follows; input, process, output, social environment and physical environment. A connection with these elements in the measurement of innovation and design activities as a whole has been weak, but now these will be covered by the new approach.

In this paper the theoretical background of design and innovation process front-end itself is described first (1). Second (2) the understanding of the radical innovation context is illustrated. Third (3) the viewpoint of social environment is discussed. Fourth (4) this is followed by a description of a physical environment of innovation process front-end. Fifth (5) the most crucial points from the viewpoint of measurement in the front-end stage of discontinuous innovation process are discussed and the idea for the new Balanced Design

Front-End Model (BDFEM) is presented. After the theoretical part, sixth (6), the methodology and first managerial implications from three Finnish manufacturing companies are described. Finally seventh (7) the conclusions of the study are discussed.

2 Theoretical background

2.1 Front End process

The foundation for successful product development is created in the front-end phase, which refers to the activities that take place before the formal development project phase [15]. The overall structure and the main characteristics of the future product are all decided in the front-end phase, which then strongly affects subsequent new product development activities. Recent studies indicate that these early front-end activities represent the most troublesome phase of the innovation process, and at the same time one of the greatest opportunities to improve the overall innovation capability of a company [15], [13]. The front-end phase nourishes the new product development project phase by producing new incremental and radical product concepts. The front-end phase results in a well-defined product concept, clear development requirements and a business plan aligned with the corporate strategy [13]. In addition, the front-end phase may produce a formal project plan including resource needs, schedule and budget estimates, and the decision on how the product concept will be developed further [12]. The decision could be to continue with an immediate development project or to put the concept 'on hold' to wait for more suitable timing, or even to kill the initiative.

2.2 Radical innovation process

Radical innovation is defined as one with the potential to produce either one or more of the following things: an entirely new set of performance features, greater than five-fold improvements in known performance features and a significant reduction cost, over 30 percent [20, pp.17], [16].

Radical innovation can be a product, process or service with either exceptional performance features or familiar features that offer significant improvements in performance or costs that transform existing markets or create new ones [16, pp. 102].

Commercializing new technologies or services for markets that may not yet even exist, the arena of radical innovation can be characterized as turbulent, and uncertain, even chaotic. Therefore radical innovation projects require different kind of competencies than incremental innovation projects. Incremental innovations often follow a more linear, orderly process with less organizational and resource uncertainties. [16] However, the reason for the great value of radical innovations is that the companies that have succeeded over the long haul punctuate ongoing incremental innovation with radical innovations that create new markets and business opportunities [16]. In the next breath must be noted that the radical innovation is like a start - up for a continuous improvement, i.e. incremental innovations, through which the gains of radical innovation are sustainable.

2.3 Social environment

Because social environment includes so many elements in itself, there are many perspectives through which it can be perceived. The social environment could be understood as referring to organisational climate, which includes the shared cognitions and perceptions of organisational members [19]. For example West and Anderson [5] have developed a model of group climate for innovation stating that four factors – vision, participative safety, task orientation, and support of innovation – are predictive of innovativeness in a work group. Another perspective to the social environment is the organisational culture. Numerous studies have listed features of organizational culture that are found to be beneficial for innovation [10], [14].

While these perspectives are central and valuable in understanding the elements that support innovative activity of organization, we find that these features of organisational climate and culture remain in quite an abstract level. Thus, we find it useful here to approach the social environment from a more action-oriented perspective. Also, we do not find the social environment to be a stable social "space", but a dynamic construct involving interaction, practices and activity. The bases of the innovation activity of the work community are innovativeness and creativity.
In generally, culture and organizational climate area has traditionally not got much emphasis in measurement literature [2].

2.4 Structural environment

As compared to the impact of the physical work environment on work processes in general, its impact on the innovation process or even on creativity in particular is still highly debated in literature. However, these to issues need to be treated differently. The process of innovation, though not being simply replicable, is being fairly well researched – especially when it comes to the later stages in the process. In its very early stages, where innovation is a lot about creativity and idea generation, this process is still to be fully understood. Therefore one needs to distinguish precisely between the impact of the physical environment on innovation and its impact on creativity.
Earlier research suggests that the physical environment indeed influences innovation efforts. For example, based on their findings at a large telecommunications company Haner and Bakke [9] state "that environments influence innovation – both in positive and negative ways". Among others, positive effects of the newly created work environment were particularly related to improved communication and cooperation.
Such findings help to establish the link between the physical environment and innovation. Further more, these (and other) factors allow measuring the impact of the physical work environment on the work process in general and the innovation process in particular.
Acording Holbek [3] innovating organizations must adopt contrasting structures and climates as they move from the initiation to the implementation stages of innovation. Chesborough and Teece [3] and Burns and Stalker [4] have also found that there is a relationship between organizational design and type of innovation.

2.5 Measurement

Several different kind of measurement gaps have been identified in literature [2]. These gaps can be categorized in two types: validity gaps and omission gaps. Validity gaps arise when there is insufficient evidence that proposed measures actually do capture drivers or outputs of innovation management. Omission gaps occur where the importance of an aspect of innovation management is supported in the literature, but measures for this aspect are lacking.
The radical innovation should be measured differently than more conventional projects, since forcing people to follow rules designed for measuring incremental change will suffocate innovation [20]. The measuring system is designed for evaluating actions aiming to produce profit in short-term period. The same measures are not valid for evaluating actions in radical innovation projects, which differs quite lot from traditional projects and the time span is on long-term period. Usually radical innovation projects change direction several times from idea conception to implementation. In the very early phase of the project the focus should be on learning, focusing and redirecting instead of reaching the milestones. Strict financial analysis or justification too early in the project can be misleading, because of the problems with market analysis [20].
The new measurement method concept proposed next comprises four stages: selection of measurement criteria (BDFEM-model), selection of data sources, data collection and analysis of results.

We call this four stages entity as the Balanced Design Front End Method, BDFEM-method. In this paper we concentrate on the selection of the measurement criteria stage, called Balanced Innovation Front End Model, BIFEM-model. Based on the earlier research [11], [18], [6], [7] the structure of the BDFEM-model model lies on the structure of the Quality Maturity Method QMM and assessment method for national technology programs in Finland. The mentioned methods consist of a three-step procedure for the setting of objectives where the objectives of a technology program are divided into impacts, outputs and activities. After we have linked objectives with attributes we have got the entity of measurable criteria. In this paper dealing with the criteria we concentrate only for the objectives viewpoint and leave the attributes discussion to the future research.
Thus, in this paper two most crucial research questions are:

- What are the objectives of measurement in radical design? and
- What are the most crucial challenges related with the selection of the relevant measurement objectives?

In the selection of objectives we have several challenging issues to take into account. What is the reliability of potential objectives? Is there any reference data related to the objectives collected in an earlier measurements of the same company or in other partner companies? What other things than the product development have an effect on achieving the impacts? Also, it is important to see the entity of measurement criteria and interrelationships between the different factors [12].
Based on the theoretical part of this paper, our framework of the model for measuring the innovation activities front end contains five assessment viewpoints as follows; input, process, output (including impacts), social environment and structural environment.

3 Methodology

3.1 Case companies

In this study, we have examined three manufacturing industry companies. Case company A is a global industries equipment manufacturer, Case Company B is a global base metal industry company that also manufactures its own products and Case C is a animal food industry company. A common characteristic of the three case companies is that the industry is investment–intensive and they have their own research units or strong external research partners.

3.2 Data collection and analysis

The data has been collected by semi-structured interviews and the data source in each company has been their CTO. Before asking the questions we found out what a radical innovation means in companies context and clarified what we mean by the concept of front-end. First the data has been analysed by comparing the emphasis of the companies' answers in terms of each five BDFEM- model measurement areas. The second analyse viewpoint has been how the criteria are categorized on the five assessment areas. We were also interested in the most crucial challenges related to radical innovation front End measurement in each company.

4 Results

The results have been shown in Table 1. The identified measurement objectives focused mainly on the innovation process's three main areas: input, process and FE output. The main focus was clearly on FE output objectives. We have divided the output objectives in two sub-categories: impact objectives and outcome/ selection objectives.

Table 1. Interview results: Identified measurement objectives in radical context

Typical innovation measurement objectives and areas in literature [1]					
	Input	**Process**	**Output**	**Social factors**	**Structural factors**
	Innovation strategy, People Physical and financial resources Tools, New knowledge	Project efficiency, Knowledge management, Knowledge repository, Optimization tool use Information flows Innovation strategy Strategic orientation Strategic leadership	Risk/return balance, Market research Market testing Marketing and sales	Culture, Communications Collaboration	Structure
Identified measurement objectives areas in radical context					
Case A Equipment manufacturer	**Input**	**Process**	**Output of Front End**	**Social factors**	**Structural factors**
	Market area's novelty	Turnaround time	Number of projects where the role of R&D centers is important	Experience	Structure/ roles of the organisation -RTD -Engineering -Marketing and sales
	Market size	Cash flow	Number of projects where the role of R&D centers is crusial	Knowledge and understandinf of the operating environment	Structure of the teams -Technological competence -Social competence
	Competitors	Technology parameters	Alternative concepts	Innovation activity	ICT systems (ERP, CRM) work in business unit/ company level
	Lead customers	Investment costs	Demo installations	Ability to create ideas	
	New opportunities to replace old technologies	Operating costs	Utilisable results in other projects	Local teams vs. Global teams	
	New industries, with the possibility of long-term success	Raw material base	Customer feedback	% of the work in -Informal teams -Formal teams -For team alone -Not for team/ alone	
	Suitability into new markets	Alternative process flowcharts	Cash flow		
			Risk -Probability to be successful		
		Customer requirements	New products/ Turn over %		
			Number of commercialised new products		
			Number of invention notices		
			R&D results related Stock Exchange Releases		
			The customer's competitive advantage factors		
			Is the project's argumentation sufficient in the commercialization		
Case B Metal industry	**Input**	**Process**	**Output of Front End**	**Social factors**	**Structural factors**
	Strategic fit	Cass flow	Stage gate objectives	Ability to get along	Physical proximity of the team
	New technologies	Competences	New meters to replace the tonnage meters - increase in strength, the number of devices	Sociality	
	New global trends like energy efficiency	First in the market	New meters to replace the tonnage meters	Suitable values	
	the business environment data and new business environment trends			Cross Functionality	
	The development of the industry				
	Potential customers and sub-customers segments				
	Business intelligence data				
Case C Animal feed industry	**Input**	**Process**	**Output of Front End**	**Social factors**	**Structural factors**
	New research results	Development costs	Suitability for the market	Right partners	Availability of research techniques and equipments
	New technologies	Risk level	Suitability for the existing product portfolio	Added value of networks	Manufacturing capabilities
	Competence networks	Feasibility	Suitability for to distribution channels	Dealer selection criteria	
		Chance of success	New use for current markets		
		Technology maturity	Criteria and scoring system for the concept selection		
		Possibility to go into new markets	Life cycle criteria		
		The price of needed technologies			

The most interesting main result seems to be that impact objectives are typical incremental innovation objectives whereas the outcome/selection objectives are trying to minimise the risk and uncertainty. And thus, find new ways to ensure that the output is relevant enough to further development, more or less under the rules of incremental innovations.
The second analyse viewpoint is how the criteria are categorized under the five BDFEM-assessment areas. We show the answer in the order as follows: input, process, output, social factors and structural factors.

Input objectives: New markets and new technologies are typically used dimensions that can be used to assess the radicalness of idea or innovation. The input responses (Table 2.) were found in both categories, but the focus was in particular on the input objectives in the assessment of market uncertainty and new market potential. The technology aspect highlights in particular how new or existing technologies should use to meet the new challenges.

Table 2. Input objectives

Categories	Input
Business Intellicence and Market oriented objectives	Strategic fit
	Market area's novelty
	Market size
	Competitors
	Lead customers
	Suitability into new markets
	Potential customers and sub-customers segments
	New industries, with the possibility of long-term success
	The business environment data and new business environment trends
	Business intelligence data
Technology and competence oriented objectives	New technologies
	New research results
	New opportunities to replace old technologies
	New global trends like energy efficiency
	The development of the industry
	Competence networks

Process objectives: A process related results are divided into two categories (Table 3.): cost-oriented and requirement-oriented objectives. Cost-oriented objects are comparable to those used in the incremental innovation indicators. The only exception is the level of risk evaluation. In contrast the requirement related objectives are more radical oriented and emphasize the possibility to go to new markets and the new competence and technology based objectives.

Table 3. Process objectives

Categories	Process
Cost-oriented objectives	Investment costs
	Operating costs
	Development costs
	Risk level
	Turnaround time
	Cass flow
	The price of needed technologies
Requirement oriented objectives	First in the market
	Possibility to go into new markets
	Chance of success
	Customer requirements
	Raw material base
	Alternative process flowcharts
	Competences
	Feasibility
	Technology maturity
	Technology parameters

Output objectives: Front End phase ends typically with the concept assessment and selection. Found objects are divided into two categories (Table 4.): outcome/selection objectives and impact objectives. The radical level of impact is highlighted in assessing a research unit's role in the development of new concepts. Outcome and selection objectives contain a lot of concept development related issues that that are typical for radical innovations. Alternative concepts, demos, utilisable results in other projects and whole new metrics are good examples of radical oriented measurement.

Table 4. Output of Front End objectives

Categories	Output of Front End
Outcome and selection objectives	Alternative concepts
	Demo installations
	Customer feedback
	Utilisable results in other projects
	• Minimising of uncertainty"
	• Probability to be successful
	The customer's competitive advantage factors
	Is the project's argumentation sufficient in the commercialization
	Suitability for the market
	Suitability for to distribution channels
	New use for current markets
	Stage gate objectives
	Criteria and scoring system for the concept selection
	New meters to replace the tonnage meters
	• increase in strength,
	• the number of devices
Impact objectives	Number of projects where the role of R&D centers is important
	Number of projects where the role of R&D centers is crusial
	Cash flow
	New products/ Turn over %
	Number of commercialised new products
	Number of invention notices
	R&D results related Stock Exchange Releases
	Suitability for the existing product portfolio
	Life cycle criteria
	Risk level

Social factors: Social and physical factors are enablers for innovation activities. Radical innovation context requires often new kind of innovation climate. The social factors (Table 5.) are divided in to two categories: internal and external objectives. In the radical context these objectives emphasise collaboration and communication, values, sociality, team work and cross functionality. Internal objectives emphasise the importance of the value chain and business networks.

Structural factors: The structural factors (Table 6.) are divided in two categories: organisational and system/technology oriented objectives. Radical innovations might need new kind of roles, tools and organisational changes to have all necessary information and competences in use. Mentioned objectives in both categories emphasise the importance to assess these objectives and change every day practices.

Table 5. Social factors

Categories	Social factors
Internal objectives	Culture
	Communications
	Collaboration
	Experience
	Knowledge and understandinfg of the operating environment
	Ability to create ideas
	Ability to get along
	Sociality
	Suitable values
	Innovation activity
	Local teams vs. Global teams
	"% of the work in
	• -Informal teams
	• -Formal teams
	• -For team alone
	• -Not for team/ alone"
	Cross Functionality
External objectives	Right partners
	Added value of networks
	Dealer selection criteria

Table 6. Structural factors

Categories	Structural factors
Organisation-oriented objectives	Physical proximity of the team
	"Structure/ roles of the organisation
	• -RTD
	• -Engineering
	• -Marketing and sales"
	• "Structure of the teams
	• -Technological competence
	• -Social competence"
System and technology-oriented objectives	ICT systems (ERP, CRM) work in business unit/ company level
	Availability of research techniques and equipments
	Manufacturing

5 Conclusions

We conclude that the framework of the model for measuring the innovation and design front end in radical context contains at the first draft five assessment viewpoints as follows; input, process, output, social environment and structural environment. A connection with these elements in the measurement of innovation activities as a whole has been weak, but now these will be covered by the new approach, BDFEM. In our research we are just now in the process for the first managerial implications of BDFEM in Finnish, Danish, German and USA companies.

Based on the results from our first managerial implications in three Finnish companies the following subjects should be taken into consideration in the application and further development of the model:

1. The current situation and the nature of the each company should be taken into careful consideration in the applications of the model. The subjects described in the model are not suitable for all companies but the appropriate tools could be chosen for a single company.

2. The model should be defined for a practical tool for managers. This assumes cultivating the model description into a concrete assessment and design tool. It should also be noted that the model is primarily a tool for internal assessment (evaluation) which is also clearly related to external audits of companies.
3. The reliability of the data collected by the model should be considered critical. This is especially important when the data collected in internal assessment is also used as basic data for the external audits. Special consideration should be given to the sources of information used in the internal assessment: how much information is collected from external experts and from other objective data sources, like documents.
4. Definition of the criteria to be assessed is the most critical stage of the measurement. The central issue is to define sub-criteria supporting the main criteria for a single case. That would enable a clear interpretation of the criteria in two viewpoints: from the viewpoint of innovation front-end and from the viewpoint of discontinuous innovation.
5. The linking of measurement with company strategies should be improved. Corporate strategy work performance could be intensified by inviting experts who have participated in defining operative level measurements: incremental and radical. Strategies are seldom written in an easily understandable language. The hearing of the measurement experts in the management would enhance the linkage remarkably.
6. Special consideration should be given to front-end impacts: what is the next step after the conceptualization? Networking in the company should be studied more. The front-end impacts in the company could in the future be divided into the following main criteria:
    - including changes at the interface and new cooperation parties,
    - internal impacts on the development phase, such as profitability and export,
    - better understanding of risks and uncertainty and
    - internal organisatory changes.

The developed model is flexible and can also be applied extensively to other purposes than manufacturing companies. The study has been mainly targeted this far to the manufacturing industry from the viewpoint of production of goods. In this study the first observation experiences show that the new measurement model might be useful on the other industrial areas, like service sector, as well. 'It is not enough to do things right; the right things must be done.'

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